tinctly separated from the seventh than are the other segments from each other, without hairs, but armed with two pairs of terminal hooks; the upper or anterior pair blunt spine-like, approximated and stout at base, somewhat appressed but not terminally recurvate or hooked; the lower or inferior pair more removed, terminally recurved below, sharp claw-shaped, slightly divergent, directed inferiorly; anterior to the latter on ventral surface there is a pair of small tubercles. Ten pairs of stigmata or spiracles, as follows: Prothoracic spiracle on side at anterior margin of prothorax; mesothoracic spiracle on anterior border of wing bases; metathoracic spiracle in the anterior lateral angle of dorsum of scutellar segment; and an abdominal spiracle in the anterior lateral corner of dorsum of each of the abdominal segments 1 to 6, the 7th segment having a small median lateral one higher up on side of dorsum; the spiracles (except the mesothoracic) appear as a corneous circle marked by radiating lines within, those on the 7th segment showing this structure less distinctly, while the mesothoracic spiracle is indistinct and does not usually reveal this structure at all.

Length, 8.5 mm. (including cephalic horns); width of basal abdominal segments, 2.25 mm.; length of long filament-like hairs of 3d to 5th segments about 3 mm., those of 1st and 2d segments over 4 mm.

THE PRIMITIVE NUMBER OF MALPIGHIAN VESSELS IN INSECTS.—I.

BY WILLIAM MORTON WHEELER, PH.D., CHICAGO, ILL.

Since the days of Schwammerdam anatomists have most naturally evinced far greater interest in the physiology than in the morphology of the Malpighian vessels. Hence we are in possession of a much larger body of facts bearing on the function than on the phylogenetic history of these interesting organs. Their possible relations on the one hand to the tracheæ, which have a somewhat similar orgin, and on the other to vermian nephridia, which have a similar function, are still shrouded in the deepest obscurity. Before these fundamental questions can be answered satisfactorily, it will be necessary, I believe, to come to some definite conclusion in regard to several minor questions. Foremost among these is the question as to the primitive number and arrangement of the organs under consideration.

No fact in insect development is better authenicated than the derivation of the Malpighian vessels. It was Bütschli* who in 1870 first showed that in the bee the paired excretory organs arise as hollow diverticula of the hindgut which itself arises as a more extensive invagination of the ectoderm at the caudal end of the embryo. All succeeding writers have confirmed this observation.

It is worthy of note that there is extensive variation in the time at which the vessels make their appearance in

*Zur entwicklungsgeschichte der biene. Zeitschr. f. wiss. zool. 20. bd. 1870, p. 541.

different insects. In some cases, as in the Coleoptera and Hymenoptera (Doryphora, Chalicodoma), they are budded off from the hind-gut when the latter is still very shallow and the embryo comparatively young. In other cases they arise late in development after the hind-gut has reached a considerable length (Orthoptera: Blatta, Xiphidium, etc). Notwithstanding these variations, the derivation of the hind-gut and its appendages from the ectoderm is so easily ascertained that it cannot escape even a very careless observer.*

The few accounts concerning the origin of the Malpighian vessels in Myriopoda are quite definite. According to Heathcote† in *Julus terrestris* a single pair of vessels is formed as outgrowths from the hind-gut, and Metschnikoff‡ long ago made a similar observation on *Strongylosoma guerinii*. Zograffs'§ figures show conclusively that the Malpighian vessels of Geophilus form no exception to the general rule. It is, therefore, quite certain that the Myriopoda and Hexapoda, which I propose to unite under the term EUTRACHEATA, agree in the mode of origin of the excretory organs. These may therefore be regarded as strictly homologous in the two groups.

Far less satisfactory are the accounts concerning the so-called Malpighian vessels of other Arthropods. Among the Crustacea (Amphipoda) two, (or in Melita only one) tubular diverticula of the mid-gut have been called Malpighian vessels, on account of their resemblance in form and function to the excretory organs of the Eutracheata. But there is this great difference: the Crustacean vessels are not derived from the ectoderm but according to Spencer* and Mme. Pereyaslawzewa,† from the entoderm.

Peripatus, I need hardly state, has no Malpighian vessels, the numerous pairs of nephridia subserving the excretory function.

In the Arachnida a pair of branching tubules opening into the mid-gut near its junction with the hind-gut have been called Malpighian vessels. There are, however, reasons for doubting their homology with the urinary organs of insects. Loman‡ believes that they correspond to the mid-gut diverticula of the Arthrostraca and maintains that they do not contain urates. The accounts of their origin in the embryo are con-

* According to Graber (Vergleichende studien, etc. Denkschr. d. k. akad. d. wiss. bd. 56, 1889, p. 25 et seq.), the hind-gut probably arises from the mesentoderm in Musca. This if true would make the Malpighian vessels mesentodermic. I have elsewhere pointed out (Psyche, June 1891, p. 98) what appears to me to be the true explanation of the phenomena observed by Graber.

† The early development of *Julus terrestris*. Quart. journ. micr. sci., vol. 26, 1886, p. 461.

‡ Embryologie der doppeltüssigen Myriapoden. Zeitschr. f. wiss. zool. bd. 24, 1874, p. 262.

§ Material k moznania embrionalnavo razvetia *Geophilus ferrugineus* Lk. e G. *proxmius* L. K. Trudi zool. mus. Moscow, 1882.

* The urinary organs of Amphipoda. Q. journ. micr. sc. (2) v. 25, 1885, p. 183–190.

† Etudes sur le développement des Amphipodes. 1. Le développement de *Gammarus poecilurus*, Rhk. Bull. soc. imp. nat. d. Moscou, no. 2 année 1888.

‡ Ueber die morphologische bedeutung der sogenannten Malpighischen gefässe der echten spinnen. Tijdschr. nederl. dierk. 5 deel. 1, 1887.

flicting and somewhat unsatisfactory. In the scorpion according to Laurie* the vessels arise as tubular outgrowths of the mid-gut. Derivation from the ectoderm is in this instance precluded, since the hind-gut, or proctodaeum, does not make its appearance till after the Malpighian vessels have arisen. On the other hand Morin,† Schimkewitch‡ and Locy§ are of the opinion that the vessels in the Araneina are budded off from the distal end of the hind-gut in much the same manner as in insects. The only remaining possibility; viz., the derivation of the Malpighian vessels from the mesoderm is advocated by Kishinouye.‖

These wide differences in opinion regarding the origin of the Malpighian vessels in all Arthropods, excepting the Eutracheata, commend us in doubting the homology of the various organs hitherto comprised under the same name. In default of definite proof of entodermic origin in the vessels of Crustacea and Arachnida, the suggestion of a new terminology would, of course, be premature. But even if the organs in question should be ultimately shown to be ectodermal in the lower Arthropods, as well as in Eutracheata, the few conclusions advanced in the present paper will be in no wise affected thereby, since I do not undertake to establish the ancestral number of Malpighian vessels for the Arthropoda as a class but only for the subordinate group Hexapoda.

Both the peculiar numerical constancy of the Malpighian vessels within limited groups of Insecta, and the great numerical disparity between different groups, could not fail to attract the attention of the entomotomist. Brauer,* especially, has made use of these conditions in his classification of insects as Polynephria and Oligonephria. It was also readily seen that the Malpighian vessels when limited in number are, with very rare exceptions, arranged in pairs. Hence Gegenbaur† and others have drawn the correct inference that the paired arrangement represents a primitive feature. It was furthermore observed that embryos and larvae of polynephric forms have a much smaller number of vessels than the corresponding imagines; the converse being very rarely, if ever the case. When, within more recent years, the great phylogenetic value of the embryonic stages was established, it was readily surmised that the condition of the excretory organs in the embryo might furnish some clue to their ancestral number and arrangement. The interesting facts brought to light by the study of the embryonic excretory system of vertebrates certainly justify

*The embryology of a scorpion (Euscorpius italicus). Q. journ. micr. sc. vol. 31, 1890, p. 128.

† Zur entwicklungsgeschichte der spinnen. Biol. centralbl. bd. 6, 1887.

‡ Etude sur le développment des araignées. Arch. biol. tome 6, 1887.

§ Observations on the development of *Agelena nævia*. Bull. mus. comp. zool. vol. 12, no. 3, 1886.

‖ On the development of Araneina. Journ. coll. sci. im. univ. Japan. v. 4, pt. i, 1890.

*Systematisch zoologische studien. Sitz.-ber. math. naturwiss. klasse. k. akad. wiss. 91, bd. 1. abth. Wien. 1885.

† Grundriss der vergeescheinden anatomie. 2. auflage. Leipzig, 1878, p. 292.

us in looking for important revelations in other descendants of annelid-like forms. Taking the embryo as our main guide in determining questions of primitive number and arrangement, we find the possible hypotheses on the Malpighian vessels to be quite limited; since *in no insect embryo have more than three pairs of these vessels been found.*

Gegenbaur* observed the frequent recurrence of the number two (some times expressed only in the common openings of numerous vessels) throughout all the divisions of the Arthropoda. Hence this number, he concludes, may be regarded as primitive. It is obvious that this statement may be correct for the Arthropoda in general and still in no wise conflict with the view that the ancestor of a particular subgroup may have had more than two Malpighian vessels. Thus Protentomon may have had several pairs and these, if ascertainable, might be regarded as constituting the typical number for the Hexapoda. The remote ancestor of Protentomon may have had but a single pair.

Two views have been advanced as to the number of Malpighian vessels in primitive insects. Paul Mayer,* in his well known treatise, expressed himself very clearly on this subject. After doing full justice to all the facts at his disposal he concludes: "Dass die anzahl der paare bei Protentomon 2 betrug, ist so gut wie sicher." The embryological evidence accumulated in 1876 was perhaps too meagre to lead to any other conclusion.

In two recent papers Cholodkowsky† advances the opinion that the primitive number of Malpighian vessels in insects is two. He bases his conclusions on some very interesting observations, to which I shall have occasion to revert, when I come to consider the Lepidoptera.

My own observations on the embryos and larvæ of several insects, together with the facts recorded by other observers, lead me to the conclusion that the ancestral number of Malpighian vessels in insects was six. In other words, Protentomon was not only hexapodous but also hexanephric.

* l. c. p. 292.

* Ueber ontogenie und phylogenie der insekten. Jen. zeitschr. naturwiss. 10 bd. 1876, p. 142.

† Sur les vaisseaux de Malpighi chez les lepidopteres. Compt. rendus. tome 98, p. 631–633, 1884. Sur la morphologie de l'appareil urinaire des lepidoptères. Arch. biol. tome 6, fasc. iii, 1887.

BRIEF NOTES.— Thorell has just published a second octavo volume of about 500 pp. on the spiders of Indo-Malesia. It is devoted to the lower groups, and closes with a table of the geographical distribution of the 462 spiders so far known from that region.

Our students of Neuroptera will be grateful to Nathan Banks for his Synopsis, catalogue and bibliography of the neuropteroid insects of temperate North America just issued in the transactions of the American entomological society. The tables are very simple and brief, perhaps erring in this latter feature.

Interesting recent papers on relationships among butterflies will be found in Spuler's Zur stammgeschichte der Papilioniden (Zool. jahrb., vi, 34 pp., 2 pl.), and Haase's Entwurf eines natürlichen systems der Papilioniden (Bibl. zool., heft. viii, 120 pp., 8 pl.).